NATIONAL RESEARCH COUNCIL
COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS
2101 Constitution Avenue Washington, D.C. 20418

BOARD ON
PHYSICS AND ASTRONOMY

(202) 334-3520
FAX: (202) 334-2791
BPA@NAS.EDU

June 20, 1994

Ms. Donna R. Searcy
Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, D.C. 20554

Re: CC Docket No. 92-166

In the Matter of

Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile Satellite Service in the 1610-1626.5 and 2483.5-2500 MHz Frequency Bands

Dear Ms. Searcy:

Transmitted herewith by the Committee on Radio Frequencies, operated by the National Research Council for the National Academy of Sciences, are an original and nine (9) copies of its Reply Comments in the above-referenced proceedings.

If additional information is required concerning this matter, please communicate with this office.

Sincerely yours,

Robert L. Riemer

Robert L. Riemer
Senior Program Officer

Enclosure

cc: Members of CORF

Before the
Federal Communications Commission
Washington, D.C. 20544

In the Matter of	)	
	)	
Amendment of the Commission's Rules	)	
to Establish Rules and Policies	)	CC Docket No. 92-166
Pertaining to a Mobile Satellite	)	
Service in the 1610-1626.5 and	)	
2483.5-2500 MHz Frequency Bands	)	

REPLY COMMENTS OF THE
NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

The National Academy of Sciences, through the National Research Council's Committee on Radio Frequencies (hereinafter, "CORF"), hereby submits its reply comments in the above-captioned proceeding. CORF represents the interests of scientists involved in the Earth Exploration-Satellite Service, the Space Research Service, the Radio Astronomy Service, and other users of the radio spectrum engaged in scientific research.[1]

[1]Although these comments will generally refer to radio astronomy, it should be noted that the concerns of radio astronomers are generally shared by all passive radio users, such as those operating in the Earth Exploration-Satellite Service, and the Space Research Service.

I. Introduction

The Radio Astronomy Service (RAS) is committed to the successful outcome of the Rulemaking process, based on the agreements reached by the FCC's MSS Above 1 GHz Negotiated Rulemaking Committee (NRC) and largely embodied in the Commission's proposed rules. Radio astronomers recognize the vital importance of efficient spectrum management and spectrum utilization. During the NRC meetings the RAS made a commitment to avoid scheduling radio astronomy observations during peak Mobile Satellite Service/Radiodetermination Satellite Service (MSS/RDSS) traffic periods, to the greatest extent practicable. The RAS honors that commitment and supports insertion of the following text in the Commission's rules at section 25.213(a)(3):

> The RAS shall avoid scheduling radio astronomy observations during peak MSS/RDSS traffic periods to the greatest extent practicable.

(This is a stronger version of the coordination wording suggested by Motorola in their Comments at Footnote 41 and Proposed Rule Change at section 25.213(a)(3) and avoids some of its potential problems.)

In exchange, it is vital that scheduled scientific use of the shared band 1610.6-1613.8 MHz be protected from harmful

interference, using the procedures worked out in the NRC and largely incorporated in the Commission's proposed rules.

The RAS has invested considerable effort in the protection of the band 1610.6-1613.8 MHz. Until recently, radio astronomy observations were badly contaminated by transmissions of the GLONASS satellite system of the Russian Federation. In-band and out-of-band transmissions from GLONASS rendered useless nearly all radio astronomy observations in this important band.

The recent efforts of radio astronomers from many countries around the world, with the cooperation and help of the GLONASS Administration, are expected to return this band to scientific usefulness.

It is hoped that in the future this much less noisy band can be used by both radio astronomers and, on a shared basis, for Earth-to-space links from mobile Earth stations (MES) in the MSS, operating in accord with the limitations agreed to by the NRC, and embodied for the most part in the Commission's proposed rules.

II. Reply to the Comments of TRW, Inc.

TRW, Inc. ("TRW"), in its comments, proposes that a position determination capability (which would be necessary for MSS

operators to comply with the requirement that MES cease operations within the fixed protection zones around radio astronomy observatories in the shared band 1610.6-1613.8 MHz) should not be required of MSS systems using a beacon-actuated protection-zone system.

During the NRC meetings, the RAS agreed that a beacon-actuated protection-zone system, if one could be developed that would be theoretically and operationally practicable, would be an acceptable--even preferable--alternative to a fixed protection zone system.

However, as Informal Working Group 2 noted in its report (section 5.1.3.1): "There are several theoretical and practical concerns which must be worked out before a beacon system can be implemented as an alternative to protection zones of specified radius around designated radio astronomy observatories."

The report does not list or discuss any of those concerns, but they are serious ones. Two are mentioned here. The first concern is that a beacon powerful enough to be received by an MES would be so powerful that it would cause interference at the observatory from its out-of-band emissions, even if the beacon were located at the upper end of the band at 1626.5 MHz.

A second major concern is that all but one of the prospective MSS system operators, including TRW itself, would employ 2483.5-2500 MHz for their space-to-Earth transmissions from the satellite. Therefore, if the MES in such systems are to be simple and inexpensive, they will be equipped for only those frequencies. Consequently, the beacons at RAS sites would have to be transmitting on a frequency somewhere in the band 2483.5-2500 MHz to be received by those MES. Thus, the MSS System Control Center, or the MES themselves, would then have to extrapolate the signal strength received at around 2500 MHz, to estimate the signal strength that would be received at the RAS site at 1600 MHz from those MES.

Because of possible differences in propagation at the two frequencies, a sizable safety margin would be required to prevent interference to RAS facilities. That safety margin could result in requiring that MES actually be farther away than they would have to be using the fixed protection zone method. Alternatively, all MES would have to be equipped to receive a beacon in the 1600 MHz band, thereby increasing their cost and complexity. Moreover, implementing a beacon-actuated protection-zone system could be impracticable even at 1.6 GHz because of the

difference in propagation between 1613.8 MHz and 1626 MHz on any long path with significant scattering from objects.

With those concerns and unknowns, among others, it should not be assumed that implementing a beacon-actuated protection-zone system will be practicable, and it would therefore be premature to delete, as TRW has suggested, the requirement in the proposed section 25.213(a)(1) that MSS systems must have a position determination capability. It should be noted that Motorola, the prospective MSS system operator that initially developed the beacon-actuated protection-zone system and described and proposed such a technique during the meetings of the NRC, has not, in its Comments, suggested any greater status for beacon-actuated protection-zone systems than that proposed by the Commission. Nor has Motorola, or any other prospective operator, suggested deletion of the position determination capability requirement put forth by the Commission.

The proposal of TRW that the Commission delete the requirement for position determination capability is perplexing, given the fact that it proposes to provide exactly that kind of service:

> Odyssey [TRW's name for its system] will provide the following public benefits: Radiolocation . . . to mobile users in all 50 states and U.S. territories . . . (Application, page 5).

Neither the theoretical feasibility nor the operational practicability of a beacon-actuated protection-zone system has been demonstrated, and the Commission should not adopt any rules predicated on the assumption that implementation ever will become feasible and practicable. The Commission should only provide the opportunity for such systems to be used instead of a fixed protection-zone system, as it has in proposed section 25.213(a)(1)(vi).

TRW proposes that the grant of interference protection for additional RAS sites should be subject to public comment. CORF does not oppose this proposal.

TRW also proposes that out-of-band emission limits from the band 1613.8-1626.5 MHz should be expressed in megahertz, not hertz. This proposal ignores the fact that RAS spectral line measurements are made using a bandwidth of 20 kHz or less. Limiting the total power over a range as wide as 1 MHz would permit spikes of spectral energy of much higher power within the actual much narrower measurement bandwidth. For example, if all the power permitted in a 1 MHz bandwidth were to be concentrated in a 20 kHz measuring bandwidth, the interfering spectral spike would be 17 dB above the limit. Therefore, CORF strenuously

opposes the use of a reference bandwidth larger than 10 kHz in this band.

III. Reply to Comments of Constellation Communications, Inc.

Constellation Communications, Inc. ("Constellation"), in its Comments, states that about 5% of the area of the United States will fall within the protection zones recommended by the NRC and proposed by the Commission. But the percentage of MSS customers that would be affected is considerably smaller. The fraction of time that all radio astronomy observatories in the United States will be scheduled to make observations in the 1610.6-1613.8 MHz band is unlikely to exceed 25%. These observatories are all located in remote, underpopulated, and little-frequented areas, accounting for perhaps 2% of the total U.S. population. When combined with the fraction of the total MSS band represented by the RAS band (about 20%), and the intent of the RAS to avoid scheduling observations during periods of peak MSS/RDSS traffic to the greatest extent practicable, less than 1% of consumer use of the MSS service would be affected. And "affected" does not mean "denied communication"--it means that the MSS Network Control Center will assign any one of the many other available uplink channels to those few MES.

CORF takes issue with Constellation's interpretation of the deliberations of the NRC when it states that:

> . . . the level of protection from out-of-band emissions desired by the radio astronomy community would prohibit transmission [from MES] at significant distances from the RAS even at the upper edge of the band at 1626.5 MHz. Thus no agreement was reached on the question of protecting radio astronomy reception in the 1610.6-1613.8 MHz band from these out-of-band emissions.

The Notice of Proposed Rulemaking at paragraph 51 states that the NRC determined two possible methods for limiting interference to RAS sites from out-of-band emissions. There were problems associated with both of the possible methods proposed for coping with this situation and insufficient time to resolve these problems during the short term of the NRC. Members of the NRC did accept the principles that out-of-band emissions would be a serious problem at observatories, and that such emissions reaching RAS sites should be limited. The only unresolved question was the method of limitation to be employed.

One proposed method was to establish smaller protection zones for MES using frequencies outside the shared band, but within a few megahertz of the band edge, 1613.8 MHz. The second proposed method was to specify a limit on the power flux density (PFD) reaching an observatory in the shared band from out-of-band emissions. As noted in CORF's Comments, the first method has the

drawback of unnecessarily restricting the operation of those MES whose out-of-band emission levels are so low that they could operate closer to the RAS site than permitted by the arbitrarily established protection-zone radius. The second method has the drawback of being difficult to implement because of uncertainties about the out-of-band emission characteristics of all MES and about the actual propagation conditions existing at a particular observatory. In its comments, CORF proposed to resolve this dilemma by proposing that the Commission establish two interim methods, either of which could be employed at the option of an MSS operator. The first would require a protection zone of reduced radius that would have to be observed by MES within a 2 MHz frequency band above the edge of the shared band. The other method proposed by CORF would be as described above: limiting the PFD reaching the RAS site in the shared band.

Constellation makes one statement regarding the PFD levels that CCIR Recommendation 769 (formerly CCIR Report 224) identifies as causing harmful interference to RAS sites:

> While these levels were accepted during the NRC negotiations as the basis for establishing a co-channel [i.e., in-band] geographic sharing arrangement between two coequal primary services, the codification of these extremely stringent levels proposed by radio astronomers is not an acceptable method for establishing out-of-band emission limits on satellite or user terminal transmitters operating outside of the radio astronomy allocation (see footnote 58).

That conclusion is illogical and inconsistent. As CORF noted in its Comments (at page 2):

> Radio Regulation 733E (adopted at WARC-92 and incorporated in the U.S. Table of Frequency Allocations by R&O, FCC 93-547, December 13, 1993) states that:
>
> > Harmful interference shall not be caused to stations of the radio astronomy service using the band 1610.6-1613.8 MHz by stations of the radiodetermination-satellite service and the mobile-satellite services.

Since that Radio Regulation applies to all the subbands constituting the 1610.0-1626.5 MHz band, the clear intent of the regulation is to protect the RAS from emissions of MES operating anywhere in the 1610.0-1626.5 MHz band, not just within the 1610.6-1613.8 MHz portion of that band.

Constellation also denigrates the significance of the levels of harmful interference shown in CCIR Recommendation 769 by referring to "levels which radio astronomers characterize as unacceptable" (emphasis supplied) and, in another instance, by putting the word unacceptable in quotation marks, as if such levels do not really constitute unacceptable interference in the way that term is used in International Telecommunication Union parlance.

The CCIR Recommendation speaks in stronger terms than "unacceptable." The term used there is "harmful interference," which, as defined in Radio Regulation 163, is:

> ...interference which seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accord with these regulations.

The level set forth in CCIR Recommendation 769 is one that will, in fact, seriously degrade, obstruct, and repeatedly interrupt accurate observations by decreasing their accuracy by 10%. A signal just a few dB above the harmful limit can so degrade sensitive measurements as to make them completely useless.

In fact, another MSS applicant in this proceeding, TRW, has cited an instance of an FCC rule, section 74.936(b), which not only imposes strict out-of-band emission limits on a service, but also incorporates in that rule the possibility of requiring even lower out-of-band levels to avoid any remaining interference, if that should be necessary (TRW Comments, III. Interservice Sharing, Section E, Page 132, "ITFS Above 2.5 GHz"). The rule cited by TRW reads:

> All out-of-band [ITFS] emissions extending beyond [frequencies 1 MHz below the band edge, that is, into a band allocated to another service] shall be attenuated at least 60 dB below the peak visual carrier power. However, should interference occur as a result of emissions outside the assigned channel, *additional attenuation* may be required . . . [emphasis supplied].

Thus, the Commission has endorsed the principle of requiring "additional attenuation" of an unspecified amount that, in its judgment, would be necessary to reduce the out-of-band emissions to a level tolerable to the interfered-with service.

In summary, with regard to Constellation's Comments, CORF urges the Commission to carry out the intent of Radio Regulation 733E by providing protection to the RAS in the shared band from out-of-band emissions of MES through the adoption of the interim rules proposed in CORF's Comments.

U.S. radio astronomers using the 1610.6-1613.8 MHz band will require protection from out-of-band emissions of MES originating outside the United States. Particularly vulnerable sites are the National Astronomy and Ionosphere Center's Arecibo Observatory (from transmissions originating elsewhere in the Caribbean); the National Radio Astronomy Observatory's (NRAO) Very Large Array (VLA) (from transmissions originating in Mexico); and some of the NRAO's Very Long Baseline Array (VLBA) sites (from transmissions originating in Canada). Unless the United States protects its radio astronomy observatories from out-of-band emissions domestically, U.S. radio astronomers will find it difficult to obtain the necessary protection internationally.

IV. Reply to Comments of Motorola Satellite Communications, Inc.

CORF appreciates the obvious scientific and technical effort that went into the preparation of the Comments of Motorola Satellite Communications, Inc. ("Motorola"). However, having carefully reviewed those Comments, CORF disagrees with the statement that the limit on out-of-band emissions from the 1613.8-1626.5 MHz band into the 1610.6-1613.8 MHz band now being proposed by the Commission in section 25.213(a)(2) is too rigid at this stage of development of the RAS.

The first point that should be made is that an interfering out-of-band emission level of -238 $dBW/m^2/Hz$ from low Earth orbit (LEO) satellites is already a compromise accepted by radio astronomers: while CCIR Recommendation 769 intends that level to be an aggregate interference level, radio astronomers agreed during meetings of the NRC that it could be used as a single-entry level from each of a multiplicity of satellites in the same system and from a multiplicity of systems. The Motorola system, for example, will have three satellites continuously within view of every radioastronomy observatory in the United States. If each satellite complies with the limit quoted above, and the interference enters through an observatory antenna sidelobe

having a gain no greater than zero dBi, the aggregate interference level from Motorola alone will be up to -233.3 $dBW/m^2/Hz$.

Specifically, Motorola observes that LEO satellites are constantly moving and pass through the main beam of a radio telescope for only a limited period of time and therefore represent only an intermittent source of interference. But main beam interference is not the basis for the protection criteria proposed by radio astronomers. Astronomers, recognizing that main-beam interference will indeed be fleeting, have never sought protection from that kind of interference. On the rare occasions when it does occur, such interference can be, has been, and will be deleted from the measurement record.

Similarly, the calculation of interference does not assume an immobile source that would render such calculations inapplicable to moving sources of interference such as the big LEO satellites. Interference sources are almost always moving in relation to the observing antenna, either because they reach the antenna through a tropospheric scatter mode at angles of arrival that vary with time; because the antenna is moving to track a distant source, making a fixed interference source appear to be entering the antenna through different sidelobes as a function of

time; or because the interference source (such as an airplane or automobile) is actually moving relative to the antenna.

Motorola states that the 10% loss in data accuracy can be made up in an equivalent amount of added observing time. However, interference can have a wide range of statistical properties. If the 10% data accuracy loss is a systematic one, no amount of extra observing will improve the accuracy. For interference from white noise, sensitivity is proportional to the square root of observing time. In that case, a 10% loss could be made up only by increasing the observing time by about 20%.

In a reference to CCIR Recommendation 769, Motorola mentions that the Recommendation has been modified a number of times since it was first adopted in 1963. However, the threshold values in that report have remained unchanged for the past 16 years. Contrary to the impression that may be left by Motorola's remark, radio astronomers have not tightened the interference threshold for a long time.

Motorola rightly observes that interferometric measurements, such as those made by the VLBA, can better tolerate interference, and that fact is recognized by the smaller protection zones that would be established around such sites. But interferometry is not the only technique that will be used in future years by radio

astronomers. In the first place, the VLBA is suitable only for observations of extremely bright sources of small angular diameter (i.e., sources in the milli-arcsecond range). Total power measurements using single antennas (to which the limits in Tables I and II of Recommendation 769 apply) are of fundamental importance in the measurement of broad sources of low brightness temperature. They are essential to important areas of radio astronomy and will not be superseded by interferometric techniques.

Motorola states that the assumption of zero dB sidelobes is based on an "old CCIR recommendation for the sidelobe levels of communication antennas." The Recommendation in question is presumably 509-1, on the generalized radiation pattern of large antennas (that is, for values of the ratio of the antenna diameter to wavelength that exceed 150), which presents the well-known expression for sidelobe levels (32 - 25 log ϕ). It is true that sidelobe levels a few decibels lower are achievable on antennas of recent design by using offset-feed structures and other features. These features have mostly been demonstrated on antennas less than 25 meters in diameter, and it is not clear to what extent such designs are economically feasible on large antennas (25- to 100-meter diameter), although one large offset-

feed antenna is currently under construction. The sidelobe model of Recommendation 509-1 is a good approximation for most existing large antennas used in radio astronomy, in which there is a substantial public investment. It has not yet been demonstrated to what extent it will be practicable to reduce sidelobes in large antennas used for radio astronomy. Thus CORF vigorously refutes the implication in the phrase "old CCIR report" that the protection criterion for radio astronomy is based on outdated information.

If the permissible interference into radio astronomy antennas were to be based on the assumption that their sidelobes were 10 dB below isotropic, rather than the zero dB assumption used now, it would mean that almost all of the existing radio astronomy antennas would receive more interference than they could tolerate throughout a very large solid angle of sky. Furthermore, all observations below an elevation angle of about 20° would receive at least 10 dB more interference than tolerable under CCIR Recommendation 769. That would mean the loss of observations at all southern declinations.

Motorola notes that observations can be made during the late night and early morning hours when the load on MSS systems will be light. The RAS is committed to avoid scheduling radio

astronomy observations during peak MSS/RDSS traffic periods to the greatest extent practicable, as noted above (first paragraph of these Reply Comments). There will be some instances in which this is not possible. For example, measurement of the hydroxyl radiation from comets during close approach to the Sun is necessarily a daytime observation. Simultaneous observations with multiple telescopes may cross many time zones. Full synthesis with the VLA requires eight hours, often best obtained in one or a few observing sessions. But in general, scheduling of radio telescope observations away from peak MSS/RDSS traffic periods is beneficial to both the RAS and MSS. The trend toward multi-wavelength feed turrets and remote observing in radio astronomy will facilitate this trend.

One minor point: Motorola characterizes the MSS as a life-saving service. However, the MSS is not a safety service under the ITU Radio Regulations, and it should not be considered as such under the Commission's rules.

In summary, CORF appreciates Motorola's efforts in "continuing to study the impact of interference to the RA service." The RAS will participate in such efforts. In fact, Motorola scientists participate now in Study Groups of the Radiocommunications Sector and other forums along with radio

astronomers seeking better information and better solutions to the problems of interference between services.

V. Conclusion

CORF believes the only prudent course to protect the Radio Astronomy Service without placing an undue burden on the MSS is to adopt the rules agreed to by the Negotiated Rulemaking Committee and subsequently largely incorporated by the Commission in the NPRM, with the addition of a limitation on out-of-band emissions falling into the 1610.6-1613.8 MHz band, as suggested by CORF in its Comments.

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

By: 
Bruce Alberts
President

June 20, 1994

Direct correspondence to:

Dr. Robert L. Riemer
HA-562
National Research Council
2101 Constitution Ave., N.W.
Washington, D.C. 20418
(202) 334-3520

With a copy to:

Mr. Richard G. Gould
Telecommunications Systems, Inc.
1629 K Street, N.W.
Suite 600
Washington, D.C. 20006
(202) 223-4449

CERTIFICATE OF SERVICE

I, Robert L. Riemer, a Program Officer with the National Research Council, certify that in addition to the nine copies of the Reply Comments of the Committee on Radio Frequencies that were submitted to the FCC in CC Docket 92-166, copies were also deposited for first-class prepaid mailing on Monday, June 20, 1994, to the following addresses:

Robert A. Mazer, Esq.
Nixon, Hargrave, Devans & Doyle
One Thomas Circle, N.W., Suite 800
Washington, DC 20005
(Counsel for Constellation)

Michael D. Kennedy
Vice President and Director,
Regulatory Relations
Motorola, Inc.
Suite 400
1350 I Street, N.W.
Washington, DC 20005

Philip L. Malet
Alfred J. Mamlet
Steptoe & Johnson
1330 Connecticut Ave., N.W.
Washington, DC 20036
(Counsel for Motorola)

Barry Lambergman
Fletcher, Heald & Hildreth
1300 North 7th Street
11th Floor
Arlington, VA 22209
(Counsel for Motorola)

Norman P. Leventhal
Leventhal, Senter & Lerman
2000 K Street, N. W.
Suite 600
Washington, DC 20006
(Counsel for TRW)

Robert L. Riemer